FARMERS' BULLETIN 1035
UNITED STATES DEPARTMENT OF AGRICULTURE

THE FARM TRACTOR IN THE DAKOTAS

FARM TRACTORS propelled by gasoline or kerosene were used first for general farm work in the northern part of the Great Plains.

The gas-driven tractor for motive power on the farm is still in process of development, has not yet found its place on many farms where it doubtless would be an advantage, and many farmers are in doubt whether one would prove profitable or desirable for them.

The leading questions about tractors which most farmers contemplating their use want answered are:

What are their advantages and disadvantages?

What size machine will it be best to buy?

How much will it cost?

What will it cost to operate it?

Can a farmer or his help, with a working knowledge of ordinary farm machinery only, operate a tractor successfully?

How much and what kind of work will it do?

How long will it last with reasonable care?

To what extent will it displace horses?

What advantages has the tractor over horses?

What extra implements or attachments will be needed and what will be their cost?

These and other questions are discussed in this bulletin and answered so far as possible from the experiences of more than 300 Dakota farmers.

Office of the Secretary

Contribution from the Office of Farm Management

R. L. ADAMS, Acting Chief

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THE FARM TRACTOR IN THE DAKOTAS

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FIRST USED IN THE NORTHWEST.

GAS TRACTORS first came into general use for farm work in the northern portion of the Great Plains. Their introduction in this region came when great areas of new land were being opened up for settlement, and millions of acres of virgin prairie were being broken. Horses were scarce and high priced in this territory, and little feed was available. Prairie breaking with horses and oxen, both of which were used extensively in this work, was tedious. The great returns from a crop of flax or wheat from a large acreage of this newly turned land were sufficient to warrant the investment of considerable capital in an attempt to make a winning.

The earliest gas-tractor outfits, usually pulling from 6 to 12 or 14 breaker bottoms, offered a means of putting under cultivation at a very rapid rate this virgin land. The returns from the acreage planted by the use of the early outfits were such as to lead thousands of settlers to borrow money for the purchase of gas-tractor outfits.

Inefficient operation, however, with overloading, delays for repairs, crude machines, crop failures, and other difficulties, soon served to discredit the gas tractor for farm work in the eyes of a large percentage of farmers. Within a few years horses were bought, colts were raised, and much of the work which had been done previously by the large tractor outfits was performed by horses. Many of the

large tractors which had been bought at great expense were sent to the junk heap, and most of the owners and their neighbors were convinced that the tractor was unprofitable for farm operations. As a consequence, while farm tractors were developed and improved rapidly, and increased in numbers in other localities, their employment in this territory, where conditions were at first exceptionally favorable for their use, was discontinued very largely.

SMALLER AND BETTER TRACTORS MADE.

As a result of the experience with the large tractor outfits in the area mentioned, manufacturers rapidly improved their machines, and at the same time there was a decided tendency to produce smaller and less expensive outfits. While at first a six-plow machine had been considered small, within a year or two most of the outfits being produced pulled less than six plows. Many machines pulling only two plows were manufactured and sold, while three- and four-plow outfits became quite common. A tractor which, a few years before had been considered small, soon came to be considered large for general farm purposes.

For two or three years following the passing of the large tractor, farmers in the Northwest were very skeptical in their attitude toward the small outfits, and sales of these machines were decidedly limited. Within the past two or three years, however, there has been a reawakening of interest in the gas tractor on the part of farmers in the northern Great Plains region.[1] To meet the demand for information, the data contained in detailed reports received from over 300 owners of modern tractors in the States of North Dakota and South Dakota have been summarized and are presented in the following pages.

FACTS AND FIGURES FROM ACTUAL SERVICE.

The intention is to present the most important facts and figures reported by experienced tractor users for the benefit of men who are considering the purchase of tractors for use on their own farms. The figures contained herein have been taken from reports received during the fall of 1917 and the spring and fall of 1918.

[1] In order to be prepared to answer questions relating to the economic value of the tractor for farm work, the Office of Farm Management has endeavored since the first introduction of tractors to keep in touch with their development and performance in all parts of the country, and in connection with this investigation has collected data from every State in the Union, showing the results obtained from the use of thousands of tractors. From the information thus obtained, Farmers' Bulletin 963, "Tractor Experience in Illinois," and Farmers' Bulletin 1004, "The Gas Tractor in Eastern Farming," were prepared for the purpose of making available to farmers in the Corn Belt and the eastern part of the United States information relating to the use of the tractor under conditions typical of those sections.

These figures represent average results obtained in actual service, and not the maximum possibilities of the tractor. These averages are worth more to a farmer in determining the probable value of a tractor for this work than are maximum figures from tests, no matter how carefully conducted. The latter represent, at best, only a limited number of machines operated under especially favorable conditions, while the averages here given represent a large number of machines operated by incompetent as well as by competent operators, and under actual service conditions which it is exceedingly difficult to duplicate in tests. A prospective purchaser may reasonably count upon equaling the average performance of his neighbors. He should strive, of course, to equal the maximum performance of experts, but should not depend upon being able to accomplish such results in order to justify investing in a tractor. For example, an outfit with sharp, new plows, operated by an expert, may plow an acre of ground with, say, 1 gallon of gasoline; but since, under ordinary conditions, with plows that have been sharpened several times and perhaps are not in perfect adjustment, the fuel consumption will ordinarily equal at least the average given herein, it is obvious that the farmer should use the average figure in determining the probable value of the tractor for this work, rather than the exceptional figure.

This bulletin is not intended to influence the farmer either for or against the tractor as a source of power, but only to assist him in determining whether his own conditions justify the use of such power. The question whether a tractor will prove profitable on a particular farm is a problem in farm management which must be worked out for that farm. Judging by the reports of the owners, however, a gas tractor, when efficiently operated, reasonably may be expected to prove profitable on most farms of 320 acres or more, but, in the opinion of these men, it should not be expected to do so on farms of less than 250 acres. Consideration of the various influencing factors mentioned in the following pages undoubtedly will be of material assistance to farmers in deciding whether a tractor will prove a wise investment on their own farms.

DAKOTA CONDITIONS.

In both North Dakota and South Dakota farming is done on a comparatively extensive scale. Perhaps the principal difference between these two States with regard to crops is that in South Dakota corn shows a larger total acreage than any other crop on the farms where tractors have been used, the corn acreage being about 40 per cent greater than the wheat acreage on these farms. In North Dakota the higher latitude restricts to a considerable extent the grow-

ing of corn, and the corn acreage is only about one-tenth as great as that of wheat on the farms reporting using tractors.

Oats and hay are important crops in both States, and flax is grown to a considerable extent on the first breaking of new ground. Generally speaking, this is a small-grain country, practically the only cultivated crop of any consequence being corn, and this, as has already been stated, is grown only to a limited extent.

Farms are large.—The farms in both States are comparatively large, those in North Dakota on which tractors are used averaging somewhat larger in size than those in South Dakota. For the most part the land on which tractors are used is level or gently rolling and free from stones. The plowing conditions vary widely, owing to spots of heavy black soil, locally called "gumbo."[1] Plows pull hard in this soil even under most favorable conditions, and when the soil is at all dry the draft is excessive. As mentioned elsewhere, this soil, when it is too wet, has a strong tendency to pack to an extent which will injure the crop planted. The fields are large and generally regular in shape, and usually range from about 40 acres up, quarter section fields (160 acres) being quite common.

The general conditions in the States of North Dakota and South Dakota are favorable to the tractor because of the large, level fields, the fact that the tractor can be used in most of the operations involved in the raising of small grain, and that there is little cultivation or other work for which the tractor can not be used, except on those South Dakota farms where corn is the principal crop. Thus the tractor is enabled to displace horses to a greater extent than is possible in other parts of the country where the heaviest work for the horses is often work which the tractor can not do.

Both spring and fall plowing are practiced, slightly more ground being plowed in the summer and fall than in the spring. On an average about one-fifth of the lands on farms from which records were obtained are never planted to crops, although frequently land not tilled or included in the farmstead is used for pasture or for the growing of wild hay.

ADVANTAGES AND DISADVANTAGES OF THE TRACTOR.

The answers of several hundred owners to the questions, "What do you find to be the principal advantage of the tractor for farm work?" and "What are the principal disadvantages?" may be summarized as follows:

Advantages.—The saving of time, with consequent ability to have farm operations done quickly, thus covering the desired acreage

[1] Gumbo soils are fine-grained, silty, usually lacking in sand, but rich in alkaline compounds, and when saturated with water impervious and soapy or waxy in appearance and to the touch.

within the proper season, is most important and is mentioned by a large percentage of owners. Ability to do thorough work, especially in hot weather, is emphasized considerably, as is also the saving in man labor and doing away with hired help, enabling one man to farm a large acreage and thus increase the total quantity of crops which he can raise. Economy is mentioned by a larger percentage of owners in this territory than in some other parts of the country, owing doubtless to the fact that the cropping system permits the tractor to be used for a larger percentage of farming operations than in most other regions; at the same time, the cropping systems are usually such as to utilize horse labor rather inefficiently, thus making the comparison rather favorable to the tractor.

Disadvantages.—The principal disadvantage of the tractor in the Dakotas, as indicated by the reports of owners, lies in its inability to do satisfactory work under moist soil conditions. This difficulty is, of course, most pronounced in those sections where the soil is particularly heavy, and where it is necessary to do considerable work in the early spring. Some of these heavy soils retain moisture long after the frost leaves the ground, thus delaying spring work.

Difficulty of efficient operation is the next disadvantage in rank of importance as indicated by the reports. This point is emphasized by tractor owners in all sections of the country, and should be kept in mind by everyone who contemplates the purchase of a tractor. (See "Operation," on p. 26.) Expense in operation, undue increase in investment, and delays from trouble, etc., were also mentioned by a small percentage of owners. Other disadvantages were given, but not in sufficient number to warrant mention. The disadvantages are not emphasized to as great an extent as was the case a few years ago, or in nearly so many cases as are the advantages.

SIZE OF FARM AND TRACTOR.[1]

The introduction of any improved farm machine generally reduces the man labor required for any farm operation, and thus permits one man to accomplish more work and so farm more land than with the older methods. This holds true regarding tractors of sizes which will accomplish more work per day than can be done with horses. Because of the local conditions and the type of farming followed, farms in the Dakotas have always been of comparatively large size, yet 44 per cent of the farmers who bought tractors increased

[1] In all cases the size of tractor is referred to by the number of 14-inch plows pulled rather than by the horsepower ratings. This is done because manufacturers do not use a uniform method of rating their outfits, and a comparison of different tractors by their horsepower ratings is practically valueless. Grouping by the number of plows pulled, under conditions which are not only fairly uniform but which represent average conditions, offers a more reliable comparison than would be obtained by grouping according to the horsepower ratings.

the acreage which they were farming, the average increase being 139 acres. Though the adoption of tractors in any locality has invariably resulted in a marked increase in the size of farms, in the Corn Belt and other farming communities where the average size of farms was considerably less than in the Dakotas, the percentage of tractor owners who increased their acreage has usually been about 33 per cent, and the additional acres farmed would average slightly less than 100. The higher percentage of farmers in the Dakotas who increased their farm acreage, as well as the considerable amount of additional land farmed, is particularly interesting.

This increase in the size of farms is a logical result of the adoption of a labor-saving machine. Farm management studies repeatedly have demonstrated the fact that a great many farms are not large enough to furnish economical employment for the equipment which they possess. That is, the various implements are capable of doing the work on a larger acreage within the time which the seasons allow, and the purchase or renting of additional land often will increase the gross receipts considerably without materially increasing the operating expenses.

WHILE there has been a tendency to increase the size of farms throughout the country in recent years,[1] because of improved machines of various kinds enabling one man to care for the crops on an increased acreage, the influence of the tractor in this direction is much more marked than that of any other machine since the introduction of the grain binder.

LARGER TRACTORS FOR LARGER FARMS.

With the tractor, as with any other farm machine, it is important that a suitable size should be selected for a given acreage. Because of the large acreages to be plowed in the Dakotas, the small two-plow tractors have never proved popular in these States. The records obtained show that by far the largest number of machines purchased during the last two or three seasons have been the three-plow outfits, with a considerably greater number of the larger than of the smaller machines.

The recommendations of the experienced tractor owners who furnished reports as to the size of tractors which are most suitable for their farms are particularly significant. The proportion of these

[1] U. S. Census, 1910, Vol. V, p. 276.

men who bought the different sizes, together with the sizes they recommend after having used the tractor, regardless of the sizes which they own, are shown in Table I.

TABLE I.—*Sizes of tractors bought by 314 Dakota farmers, and sizes recommended after experience in their use.*

Size of outfit.	Percentage of farmers buying.	Percentage of farmers recommending.
2-plow	17	5
3-plow	56	52
4-plow	12	30
5-plow and over	15	13

These figures show that more than one-half of the men reporting own three-plow machines, the remainder being about evenly distributed among the two-plow, four-plow, and larger sizes. After using these tractors, nearly the same percentage recommend the three-plow tractors as own them, while 30 per cent recommend the four-plow outfits and only 5 per cent the two-plow machines. It is obvious from the reports of Dakota farmers that the two-plow tractor does not increase sufficiently the amount of work which one can do following the old methods, hence does not possess, except to a slight degree, the greatest advantage of tractors in general—namely, timeliness in performing farm operations through much more rapid work than is possible with horses. Moreover, a two-plow tractor does not ordinarily develop enough power to make it suitable for operating even the smallest sizes of grain separators, with the usual attachments; hence in a small-grain section, where there is a great deal of thrashing to be done and individually owned separators rapidly are becoming more common, it is not surprising that the small outfit finds little favor with farmers.

HOW SMALL A FARM CAN AFFORD A TRACTOR?

The question as to the smallest farm on which a tractor may be expected to prove profitable is often asked and has been much discussed. This obviously depends upon a number of factors, and particularly the type of farming followed. Certainly no more reliable opinion on this point for farmers in any locality could be obtained than the average of the estimates of a large number of tractor owners in that neighborhood. In the opinion of Dakota farmers the minimum number of acres on which the 2-, 3-, or 4-plow outfits may be expected to prove profitable are 185, 225, and 314 acres, respectively. Attention is called especially to the fact that these figures represent the smallest size of farm for which these tractors should be purchased, in the opinion of men who have had experience with them,

and not the size on which they can be used most profitably. A farmer who is contemplating the purchase of a tractor and whose farm is smaller than the acreage above given, should consider carefully before acting contrary to the opinions of experienced men.

While a tractor is less efficient on a small farm, because of the smaller fields and a correspondingly greater loss of time in turning, the large percentage of the area of fields to be finished up with horses when plowing, etc., these points are not so important as the fact that the small farm is usually thrown out of balance, from an economic standpoint, by the investment of a disproportionate amount of capital in power which can be used fewer days than would be the case with the same machine on a larger farm. The overhead charges per unit of work done, therefore, are much higher on the small farm. The obvious course for the small farmer who has already invested in a tractor and wishes to make the best use of it is to acquire more land in order to utilize the tractor more efficiently, which, as mentioned elsewhere, is the course followed by a large percentage of tractor purchasers. The minimum size of farms on which tractors of these sizes are recommended for Dakota conditions are considerably larger than the acreages recommended for the same-sized tractors in other sections of the country, owing doubtless to the different type of farming followed.

The average sizes of the farms reporting on which the 2-, 3-, or 4-plow tractors are used are considerably above the minimum figures given above, being 346, 389, and 489 acres, respectively, with an average of 252, 303, and 396 crop acres, respectively. There was not a sufficient number of reports on the larger sizes of machines to give a reliable indication of the average size of farms on which these tractors are used.

TRACTOR MUST FIT THE JOB.

To obtain the fullest degree of satisfaction, it is necessary that the proper size of tractor be bought. A tractor which is not powerful enough for the work required of it will prove more or less unsatisfactory, of course, and to exchange it for a larger one entails an expense which would be unnecessary if the right size were obtained at first. On the other hand, an outfit which is much too large may be too clumsy or expensive in operation to make it economical for a great deal of work on which a tractor of the proper size could be used with satisfaction and economy.

In purchasing an outfit care should be used to obtain one with ample power for the heaviest work which will be required of it. This may be either field work or belt work; probably it will be the latter more often than the former. Frequently the work of a tractor in driving a grain separator or ensilage cutter requires more power

than would be necessary for doing the plowing in good seasons, and in such cases the tractor bought should be powerful enough to handle the belt work properly. On the other hand, the belt work required of the tractor may not demand a great deal of power, while the amount of plowing to be done within a limited season is considerable. In such cases the tractor should be capable of pulling enough plows to do the work within the time available.

There are cases in which only a small amount of belt work is required, and most of the field work will be done with horses, the tractor being wanted merely to make extra power available in rush seasons, or to relieve the horses during hot spells. In such cases the small 2-plow outfits frequently have proved most satisfactory. Such an outfit has the advantage of not necessitating a large investment, and on this account is sometimes recommended by experienced men as a good size to buy at first in order to gain experience in the use and care of tractors.

If it is desired to use the tractor for custom work on neighboring farms or for road work, an outfit with sufficient power to handle such work satisfactorily should be chosen.

As a general rule it is better to err through buying an outfit with too much power rather than too little, but this should not be interpreted as recommending the purchase of the largest sizes. It refers rather to the apparently too common practice of getting a 2-plow outfit to do work which should properly be done with a 3-plow or 4-plow machine.

COST OF THE TRACTOR OUTFIT.

Though not the only consideration, the cost of a tractor is one of the first points which a farmer must consider. The prices of the different makes of outfits vary considerably for machines of practically the same capacity, owing to differences in quality, sales systems, efficiency in manufacture, quantity produced, etc. It is a grave mistake to sacrifice quality for a saving in the first cost, since in no other farm machine do reliability and serviceability count for more than in the tractor. On the other hand, it is poor management for a farmer to invest too large a part of his capital in power. The desirability is obvious of further standardization and quantity production of tractors, in order to reduce the first cost.

The price which a farmer can afford to pay for a tractor for use on his farm depends upon a number of factors, such as the amount and value of the work which the machine will perform annually, the value of the horses which it will displace, the value of the man labor saved, and the amount of increased returns which reasonably may be expected from its use.

Tractors higher priced.—Prices for both tractors and the implements for use with them have been considerably increased during the last two years, owing to the advances in costs of both labor and materials required to produce them. At the present time (1919) the cost of the 2-plow tractors ranges from about $900 to $1,200; the 3-plow machines cost from about $1,100 to $1,800, and the 4-plow outfits from $1,600 to $2,400, the range in prices depending, of course, upon the factors above referred to. In practically all cases where a tractor is purchased it is necessary to buy some special equipment for use with it, or at any rate a special tractor gang plow. The prices on the latter implement at present are approximately $125, $175, and $250, respectively, for the 2-, 3-, and 4-bottom gangs. In all cases the prices vary considerably according to the make and quality of the machines.

As information was obtained from men who had used their machines at least one season, though in no case exceeding three seasons, the cost of the outfits, the reports on which were used in the preparation of this bulletin, averaged slightly lower than the prices above mentioned, as the machines had been bought before the rise in prices.

LIFE OF THE TRACTOR.

The amount of service which a tractor will perform before it must be replaced is obviously an important factor in determining its value for farm work. Gas tractors have undergone so many changes in their process of development that it is impossible to obtain any really definite figures as to the amount of work a tractor of modern design reasonably may be expected to do before it must be replaced. Among the factors influencing the amount of service rendered by a given machine, by far the most important is the care it receives at the hands of the operator. (See "Operation," p. 26.) The quality of the outfit, the kinds of work for which it is used, and the conditions under which it is operated all materially affect its life.

Nearly all tractors are used under conditions which are extremely severe for any kind of machine. They travel over rough and uneven ground, and are subjected to severe shocks both from obstructions in the path and from the load being pulled. A still more injurious condition is their exposure to an almost constant shower of dust and dirt, which, if the soil contains much gritty substance, attacks all gears and bearing surfaces, not only those on the exterior of the machine but also those inside the engine itself, unless an efficient filter is provided for the air intake to the carburetor. This excessive wear due to dust was a very serious matter with the earlier models of tractors, but great progress has been made during the last year or two in protecting the machines in this respect.

USERS GIVE ESTIMATES.

It is obviously impossible to determine definitely the probable life of the latest model tractors, since none of them is worn out, but the nearest approximation to the actual figure would unquestionably be the average of the estimates given by a large number of men who had used them for a season or two. Tractor owners were asked for an opinion as to the number of years their own particular machines would give satisfactory service. As would naturally be expected, the average of the estimates of men who have found the tractor satisfactory and profitable was higher than of those who gave adverse reports on their machines. The average of the estimates of the first-mentioned class of owners was 9.4 and the latter 6.2 years. The fact should not be overlooked, however, that the percentage of favorable reports was considerably higher than the unfavorable, nearly 85 per cent of the owners reporting that their machines had proven profitable. The average of all estimates on the life of a tractor is almost nine years. The average number of days these machines were used annually for both home and custom work was 51. These figures, therefore, would indicate a working life of approximately 450 days. It is not believed that a prospective purchaser of a tractor should expect for his outfit a longer life than nine seasons of 50 working days each, and he would be on the safe side if he counted on a somewhat shorter period of service when calculating the probable value of a tractor for his work. These figures, of course, are based upon the usual proportions of field and belt work. A tractor wears much faster and in more parts when used in the field than when used for belt power. Where a large percentage of the tractor's work will be at stationary operations, its life in days of service will be proportionately greater.

DAYS USED ANNUALLY.

The tractors reported on the Dakota farms were used on an average about 50 days annually. The number of days a tractor can be used on any particular farm, of course, will depend upon a number of factors, such as the size of the tractor, the extent of the various operations for which the tractor can be used, and the soil conditions at the time these operations must be performed. While 50 days may appear low at first glance, it must be borne in mind that the seasons during which specific farm operations should be carried on are comparatively limited, and on farms where the work is done entirely by horses, 100 days' work annually for each work animal is about a fair average. Since the tractor in proper sizes increases the speed at which the various operations are accomplished, and a certain number of horses are almost invariably used for performing odd jobs for

which the tractor is not practicable, it is obvious that 50 days' work annually for a tractor on most farms is about all that can be expected unless a decided change is made in the farm organization so as to utilize the tractor more efficiently.

Plan to lengthen working period.—Practically all farm operations must be carried on within limited periods, and between these seasons there will often be no field work which the tractor can do, either on the home farm or for neighbors, even though weather and soil conditions are such as to permit field work with a tractor.

Efficient farm management plays an important part in organizing the farm so as to provide profitable employment for the tractor during as many days as possible. Such organization involves the planning of a crop rotation which will furnish a large amount of work which can be done by the tractor, the elimination of as many horses as desirable, and the distribution of the work over a long period. The rotation, of course, should include only such crops as can be grown profitably in the particular region.

The fact that a large percentage of these Dakota farmers enlarged their farms after buying tractors is significant when the tractor's place in farm management is thus considered. Obviously these men have learned through experience that much more land per man can be handled when a tractor is used than with horses only, and that to get the most out of their investment they must farm land enough to keep their tractors busy at profitable work throughout as much as possible of the available working season.

The following table shows the average number of days the 2-, 3-, and 4-plow tractors are used annually on the home farm and for custom work, together with the average size of farms on which these machines are used.

TABLE II.—*Average annual use of two-, three-, and four-plow tractors and average size of farms.*

Size of tractor.	Average number of days worked.			Average size of farms.	
	Home farm.	Custom work.	Total.	Total acres.	Crop acres.
2-plow	37	8	45	346	252
3-plow	41	11	52	389	303
4-plow	49	15	64	489	396

There is a regular increase in the number of days used as the size of the tractor increases. This increase is more marked under custom work than on the home farm, which is probably accounted for partly by the fact that the small machine's work on the home farm is not usually completed early enough to permit of much custom work and partly because machines of the smaller sizes are neither in as great

demand nor as profitable to the operator when used for custom work as are the larger machines.

To show the effect of the size of farm on the number of days the tractor is used annually, the reports from tractor owners were arranged in groups according to the number of crop acres, and the results are shown in the following table:

TABLE III.—*Relation of size of farm to annual use of tractor.*

Crop acres in farm.		Average number of days tractor worked.		
Range.	Average.	Home farm.	Custom work.	Total.
160 and less	127	22	19	41
161 to 320	263	38	13	51
321 to 480	405	43	10	53
481 to 640	572	54	7	61

The number of days the tractor is used annually on the home farm increases rapidly with the size of farm, while at the same time there is a gradual drop in the number of days the tractor is used for custom work as the size of the farm increases, as would naturally be expected. The figures indicate also that, even with custom work, the number of days the tractor on comparatively small farms is used annually does not equal the number of days of annual use on the large farms. In this connection particular attention is invited to the remarks under "Custom Work," on page 30. Because of the small number of days the tractor can be kept busy on the small farms, the percentage of men owning tractors on small farms who do custom work is considerably higher than on farms large enough to keep the tractor busy during most of the working season.

REPAIRS.

The amount of repairs required depends upon many factors, the most influential of which is the proficiency of the operator and the care he gives the outfit, both when in use and when idle. The conditions under which the outfit is used—that is, whether on rough ground, in dusty fields, etc.—the load it is required to pull, and, of course, the quality of the machine itself, all affect the repair bills. Many tractors are kept in repair by the manufacturer free of charge during the first year's service, excepting such items as are caused by some fault of the operator. It is not until the second year, therefore, that the owner bears the full expense.

Of 110 tractor owners in the Dakotas who had used their outfits one season or less (average age, 10 months), 38 reported that they had spent nothing for repairs. The others had repair bills varying from

a few cents to $100 or more, the average being $29, making the average repairs for the entire group about $19. Comparatively few machines go through their second season without repair charges. The average repairs for 137 Dakota outfits between the ages of 13 and 24 months (average age, 19¼ months) was $40. For 49 machines between the ages of 25 and 36 months (average age, 33 months) the average repairs amounted to $97.

These figures for the average repairs in Dakota are slightly higher in each case than for tractors of the same age working on Corn Belt farms, as shown in Farmers' Bulletin 963, "Tractor Experience in Illinois;" but the slight difference in repair cost corresponds very closely with the difference in the number of days used annually, the Dakota tractors being used on an average six days more each year than those on the Illinois farm.

KEEPING THE TRACTOR NEW.

The statement is made frequently that a tractor should last indefinitely with proper repairs, since all parts are renewable and the substitution of a new part for a worn one will make the outfit as good as new. There comes a time, however, when so many parts have become worn and need replacing that the cost of repairs is so great as to make it unwise to spend such an amount on an old machine, it being more profitable to discard it and buy a new one. Furthermore, it becomes increasingly difficult to obtain repair parts for any machine as years go by. Not infrequently a manufacturer goes out of business or discontinues the production of a particular machine, thus making it impossible, or at least very expensive, to obtain extra parts. It seldom pays to attempt to use badly worn machines where the farming system provides work for the labor and equipment during most of the working season, since such outfits may cause serious delays and a direct or indirect money loss equal to the cost of a new machine. This is especially true of the tractor.

The figures reported for repairs indicate an annual repair charge during the first three years of a tractor's life of about 3 per cent of the first cost, but this would undoubtedly increase during the latter years of its life, as is the case with most other machines. It would not seem safe to expect the cost of repairs for a tractor to average less than that for other farm machines, which is a little over 4 per cent of the first cost,[1] and it is not improbable that it will amount to slightly more than this. In figuring the repair costs to be charged against each day of use or acre plowed the average annual charge has been taken as 4 per cent of the first cost.

[1] U. S. Department of Agriculture Bulletin No. 338.

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WORK DONE PER DAY.

PLOWING.

The number of acres covered per day by a plow drawn by a tractor is usually slightly greater than that covered by the same sized horse-drawn plow. The acreage covered by two different machines, each pulling the same number of plow bottoms, often varies considerably, because they travel at different speeds, are in different kinds of soil, plowing different lengths of furrows, etc. Theoretically a 14-inch plow when drawn by a tractor should cover approximately 3 acres in an ordinary working day of 10 hours, as the average plowing speed is slightly more than 2 miles per hour. This holds true in actual practice when the plowing conditions are favorable, provided the outfit does not give trouble. That is, a 2-plow machine should plow 6 acres and a 10-plow outfit 30 acres per day, provided both travel at the average rate of speed and are kept moving. However, where trash, which frequently clogs the plows, is to be turned under, each plow drawn by a large tractor will cover much less ground in a day than one drawn by a small outfit, since the delays will naturally be in proportion to the number of plows pulled. A delay on account of 1 plow on a 2-plow outfit stops only 1 other plow, while on a 10-plow rig, for example, it stops 9 other plows. To illustrate: Supposing a man operating a 2-plow tractor were compelled to stop 10 times during the day for each plow in order to clear it of trash, and spent three minutes each time (which would not be unusual), the loss of time during the day would amount to a half hour for each plow, or but one plow-hour total loss. Each plow would have done nearly as much work as in plowing continuously. On the other hand, a man operating a 10-plow tractor under the same conditions would have to clear each plow the same number of times in proportion to the acreage covered, resulting in a total loss of three or four plow-hours during the day. In such case each plow would have done much less work than under favorable conditions.

In view of these facts it is apparent that when plowing under unfavorable conditions large gang plows do not cover as much ground per day per plow as the smaller ones. However, one man accomplishes considerably more work with the large outfits, even under such conditions.

According to the figures furnished by tractor owners in the Dakotas, the area covered per day (10 net working hours) in plowing with the tractors most commonly used is 6.3, 8.5, and 10.9 acres for the 2-, 3-, and 4-plow outfits, respectively. These figures correspond closely to the theoretical capacity of the various outfits as above mentioned in discussing the delays occurring with the different sizes

of tractors. The time spent in the field with the tractors on the farms reporting was a fraction over 11 hours, with a variable amount of time lost from different causes. The average area plowed per day, therefore, is actually slightly greater than the figures above given, since these figures are based on a net working day of 10 hours.

OTHER WORK.

The acreage covered per day at field operations other than plowing will vary, of course, with the width of the implement pulled, and this in turn will depend upon the relative draft. It is, therefore, impossible to give for such operations average figures which would be of value. In harrowing or disking, for example, the width of the implement pulled will depend upon the adjustment of the disks or harrow teeth and the depth to which the ground is being worked. The nature of the soil will also have an influence. The speed of the tractor ordinarily will not be quite as great on soft ground as where the machine has a firm footing, because of the greater slippage of the wheels. On the other hand, not so much time is lost on account of clogging or other obstructions when harrowing, disking, etc., as when plowing.

The approximate acreage covered in a day of 10 hours with implements of different widths can be determined easily by allowing about 2 acres per day for each foot of the implement's width where the outfit is working on soft ground. Where it has a good footing it may be safe to allow 2½ acres for each foot of the implement's width. The acreage covered, of course, will vary with different machines, owing to the different speeds, but the figures given are based on a speed of 2 miles per hour, with an allowance for time lost in turning and the slight overlapping, which is a trifle greater in most other field operations than in plowing.

TRACTORS DO LITTLE HAULING.

By far the largest proportion of the work done by tractors is in plowing and preparing the seedbed and in belt work. Though they are used for a number of odd jobs at different times, these represent an insignificant portion of the total work. Hauling, which usually occupies farm horses for several days annually, is not commonly undertaken with the tractor, and in most cases where it has been tried it has been found less satisfactory and more expensive than hauling with horses or trucks. To make an economical load for the tractor it is necessary to have several heavily loaded wagons, and this makes an unwieldy outfit in turning corners and in getting in and out of loading and unloading places in most towns. Other objections to the use of the tractor for hauling advanced by men

who have tried it are the heavy wear and tear on both tractor and wagons on hard roads, expense on the unloaded return trip almost as great as when loaded, and difficulty in handling heavy loads on grades. It is not surprising, therefore, that only about 14 per cent of tractor owners report doing hauling with their outfits and that on the whole hauling represents less than 3 per cent of the work done by tractors in the Dakotas.

COST OF OPERATING.

The cost of performing farm operations with the tractor is made up of four main factors; namely, operating expenses (including fuel, oil, and grease), repairs, depreciation, and man labor. To these are added some less important charges, such as interest on the investment, cost of housing, and time spent in caring for the outfit, other than repair work. In calculating cost of tractor work, the mistake should not be made of omitting any of the first four items, as each of them will amount to a considerable sum per unit of work. The others may be comparatively insignificant in some cases, although they must be included to obtain a strictly accurate figure.

To give the prospective purchaser an idea of the average cost of using a tractor, the following figures on fuel consumption, repairs, etc., are presented. From these figures for the sizes most commonly used it is believed that a farmer can approximate the costs for any other size of tractor.

FUEL, OIL, AND GREASE.

Gasoline and kerosene.—The average quantity of fuel consumed per acre in plowing for all tractors on Dakota farms reporting is 2½ gallons. This figure does not vary materially for the different-sized outfits, as long as each pulls its normal load. It is possible, however, to reduce the fuel consumption somewhat by overloading the tractor; that is, adding one more plow bottom than the machine is intended to pull. This reduces the distance the machine must travel to plow an acre, and, consequently, results in a slight saving of fuel. The saving is not in proportion to the actual distance traveled, however, since the overload involves much more slippage of the wheels and consequent loss of power. Such overloading results in more time being lost per day, and in higher repair charges, so that this practice is expensive and inexcusable except in unusual cases where speed in completing a job is of the utmost importance. If such speed is required regularly the work could be done more cheaply and satisfactorily with a larger outfit.

There is a slight difference in fuel consumption between machines of different makes, and also usually a slightly lower consumption in

some makes of tractors where gasoline is used instead of kerosene. These differences, however, do not usually amount to a great deal, and for most purposes the figure of 2½ gallons of either gasoline or kerosene per acre of plowing will be as nearly accurate as any that can be used for an average.

Kerosene cheaper fuel.—Although reports obtained in 1917 indicated that some difficulty was being encountered by owners of kerosene tractors in burning the lower grade fuel, the reports received on more recent models of tractors indicate that much less difficulty is being met with than formerly. The fact that the commercial grades of gasoline now obtainable are much lower than those on the market a few years ago probably accounts to some extent for reducing the difference between the amounts of these two fuels required to plow an acre of ground. Nearly two-thirds of the tractors on the Dakota farms are operating on kerosene, and where the machines have been especially designed to burn this fuel, the results are apparently very satisfactory, particularly in view of the present price of kerosene as compared with gasoline, the former costing a little more than one-half as much as gasoline. However, the greater ease in operating on gasoline and the somewhat greater certainty of steady operation are sufficient to cause many men to prefer this fuel to kerosene.

FUEL CONSUMPTION of a tractor is influenced considerably by the operator. A proficient operator will be able to make such adjustments as will reduce the fuel consumption to the minimum, whereas an inefficient operator, even with the same make of machine and under practically the same conditions, will frequently run the outfit in such a way as to increase unduly the amount of fuel used.

In this respect, as in others, a prospective purchaser is not safe in assuming that he can obtain better results than the average, although, of course, he should endeavor to do so. In making calculations it is best to be on the safe side. The average price paid for gasoline by the Dakota tractor owners in 1918 was about 27.6 cents per gallon, and for kerosene 15.2 cents per gallon. With these prices, therefore, the fuel cost per acre for plowing with the tractor averaged about 38 cents where kerosene was used and 69 cents where gasoline was used.

This assumes that the 2½ gallons of fuel per acre used by the kerosene tractors is all kerosene, and does not make any allowance for

warming up the engine with gasoline. All kerosene tractors start and warm up on gasoline, but the quantity used for this purpose varies greatly with the make and with the operator. The quantity of gasoline required for this purpose as reported by owners averages about 1¼ gallons per day. The amount of kerosene used per day then would be decreased by a corresponding amount. With the prices of fuel as given above, the difference in cost of 1¼ gallons of gasoline and the same amount of kerosene is about 15½ cents. Supposing the average day's plowing is 10½ acres, the added cost per acre for this gasoline over the figure of 38 cents for fuel for kerosene burners is about 1½ cents.

Lubricating oil.—The quantity of lubricating oil used per acre with different outfits showed a much greater variation than the fuel required. Some men reported using nearly a gallon of lubricating oil per acre, while some reported less than one pint per acre. The quantity of oil used, of course, will vary somewhat with the different makes of machines, but the greatest variation will be due to the idea of the operator as to the quantity with which the engine should be supplied.

It is usually false economy to cut the quantity of oil down too low, but, on the other hand, it is easy to use more than is necessary and than will really be of benefit. The average quantity of oil per acre used in plowing, for all tractors reported from the Dakotas, was about three-fifths of a quart. The size of tractor used appears to make little or no difference in the amount required per acre. With oil at 50 cents per gallon (the average price paid for it), this would amount to 7½ cents per acre. The kind of fuel used does not seem to make any decided difference in the quantity of lubricating oil required.

Grease.—The quantity of grease, or "hard oil," used also varies widely with the different machines and different operators. No attempt to obtain definite figures on this point was made, as it is of such minor importance that few farmers pay much attention to the quantity used. It is believed that the consumption will amount to about 1 pound per day on the average, and the cost is usually in the neighborhood of 10 cents per pound, thus making the cost of this item amount in most cases to approximately 1 cent per acre. At the most, 2 cents per acre should be an ample allowance.

Total for fuel and oil.—Based on the figures given above for the Dakota farms reporting, the average cost per acre plowed for fuel, oil, and grease is about 78½ cents where gasoline is used and 49 cents where kerosene is used.

REPAIRS.

Using the figures given under "Repairs," on page 15, and under "Days Used Annually," on page 13 (i. e., the average annual repair

charge as 4 per cent of the first cost and the days used annually as 45, 52, and 64, respectively), the corresponding repair charges per day for the 2-, 3-, and 4-plow outfits of average price would be 93 cents, $1.12, and $1.25. For the average acreage covered with these different-sized rigs the repair charges per acre would therefore be 15, 13, and 11 cents, respectively.

DEPRECIATION.

Assuming the average life of a tractor to be 9 years (see p. 13), the average annual depreciation of the 2-, 3-, and 4-plow outfits will be $116.66, $161.11, and $222.22, respectively. The corresponding daily charges, therefore, based on 45, 52, and 64 working days per year (see p. 14), will be $2.59, $3.10, and $3.47.

The depreciation costs per acre for the 2-, 3-, and 4-plow outfits, based on the average acreage plowed by them, as shown on page 17, will be 41 cents, 36½ cents, and 31¾ cents, respectively.

FROM these figures it will be seen that the depreciation charge is one of the largest items which go to make up the total cost of performing work with the tractor, yet it is one which many people ignore entirely when figuring tractor costs

In this case, too, a rather long life has been assumed, which makes the depreciation somewhat lower than would be altogether safe to count upon.

MAN LABOR.

Comparatively few of the Dakota tractor owners reporting hire operators, and in cases where the machine is operated by hired help, the wages paid vary widely. Some men intrust their machines to ordinary hired hands at comparatively low wages, while others attempt to secure first-class operators and are willing to pay fairly high wages to secure thoroughly competent men. The cost per acre for man labor will be considerably affected, of course, by the wages paid, although in many cases a high-priced operator may do enough more work per day partly to offset his higher wages, and by reducing operating and repair charges may much more than offset them. The greater reliability of the higher-priced operator and the consequent certainty of having the work done when desired also have a value, but this can not be calculated.

To ascertain the cost per acre for man labor in plowing with a tractor, in order to round out these cost figures, the cost for man labor has been placed at $4 per day. This is about the actual cost for

operators to many Dakota farmers when value of board, etc., is included, and is not too high a valuation to place upon the owner's time when he operates the machine personally. Using this figure, the cost per acre for man labor with the 2-, 3-, and 4-plow outfits, based on the average acreage given, would be 63½ cents, 47 cents, and 36¾ cents, respectively.

INTEREST.

The interest charge on a tractor is a fixed annual charge, and the interest cost per unit of work obviously will vary with the number of days the tractor is used, decreasing as the number of days used increases. Figuring interest at 6 per cent on the average investment (one-half the first cost) for the different-sized tractors, as shown on page 12, and assuming the average number of days used annually to be 45, 52, and 64 (p. 14), the average interest charge per day for the 2-, 3-, and 4-plow outfits will be 70, 84, and 94 cents, respectively.

The interest cost per acre, based on the average acreage covered by the different-sized rigs, would therefore be 11, 10, and 8½ cents, respectively. The increased acreage plowed per day by the 3-plow and 4-plow rigs as compared with the 2-plow offsets the increased interest charge due to higher price. It should be borne in mind, however, that the number of days used annually will cause a variation in the interest charge per unit of work.

TOTAL COST PER ACRE.

Plowing.—The approximate total cost for plowing an acre with a tractor under conditions such as are described herein, as calculated from the figures given in the preceding pages, would be as shown in Table IV. No charge has been made in the table for plow cost. Owing to the fact that tractor gang plows cost more than horse gangs, it is reasonable to believe that the cost per acre is slightly greater for the former, but the difference ought not to be great.

TABLE IV.—*Approximate cost of plowing an acre with 2-, 3-, and 4-plow tractors, based on corresponding average costs of $1,050, $1,450, and $2,000, and a life of 9 years of 45, 52, and 64 working days, respectively, per year.*

Size of tractor.	Total cost of plowing.[a]		Fuel.		Other items of cost.					
	Gasoline tractor.	Kerosene tractor.	Gasoline.	Kerosene.[b]	Oil.	Grease.	Repairs.	Depreciation.	Man labor.	Interest.
2-plow	$2.09	$1.79½	$0.69	$0.39½	$0.07½	$0.02	$0.15	$0.41	$0.63½	$0.11
3-plow	1.85	1.55½	.69	.39½	.07½	.02	.13	.36½	.47	.10
4-plow	1.66½	1.37	.69	.39½	.07½	.02	.11	.31½	.36¾	.08½

[a] The cost of housing the outfit and other minor overhead charges, such as taxes, insurance, etc., are not included.

[b] Total cost of kerosene is 38 cents; 39½ cents includes 1½ cents per acre for gasoline used in starting kerosene engines. (See p. 21.)

Other operations.—From the figures given above it will be a comparatively easy matter to arrive at relative costs for other operations with the tractor. For all field operations the daily charges for interest, depreciation, and man labor will of course be about the same, but must be divided by the acreage covered by the implement used. This acreage will vary with different implements. The fuel and oil charge will be the same for a 10-hour day in other field operations as in plowing, provided the tractor is loaded to the same extent. This, however, frequently is not the case. If a comparatively light load is drawn, the fuel and oil consumption will be somewhat reduced, but not in proportion to the load. For stationary work, if the engine is working to full capacity, the fuel and oil charges will be approximately the same as for a day's work in plowing, but no grease will be used on most machines. This, however, would be only a small item.

ECONOMY.

From the figures given above it will be noted that the cost of plowing or performing other field operations with a tractor is approximately the same as with horses, excepting for the item of man labor. This will average lower with the tractor than where horses are used, assuming wages to be the same in each case.

> **THE ADVANTAGE of the tractor, like that of most other improved farm machines, lies not so much in the reduction of the cost of performing a unit of work as in the fact that it permits one man to do considerably more work within a given period of time.**

This has been true of practically all improved farm machines, even of the grain binder, which is generally considered one of the greatest agricultural inventions of the nineteenth century, but which did not, contrary, perhaps, to general opinion, decrease the cost of harvesting wheat to any considerable extent, though it did increase about eightfold the acreage which one man could handle. (See Department of Agriculture Bulletin No. 627.)

Men who hope to reduce greatly the cost of farming operations by the purchase of a tractor should bear these facts in mind, and also the fact that comparatively few tractor owners mention as an advantage reduction in the acre cost of performing farm work. Judging by the experience of tractor users, it is not safe to expect any material reduction in the cost of farm operations per acre through the use of the tractor, but it is safe to expect to be able to increase the crop acreage to a very considerable extent, and, at the same time, the amount of crops which one man can raise.

XUM

Furthermore, it should be remembered that the cost of doing the work with a tractor as above outlined in most cases can not be compared directly with the cost of doing it with horses, since on farms where tractors are used a number of horses generally are retained; any comparison, therefore, must be made between the cost of operating the farm with horses alone and the cost of operating with the tractor and a certain number of horses. Not infrequently horses stand idle while the tractor is being used for field work because sufficient help is not available to use them at the same time, and in such cases part of the cost of their maintenance must be considered when figuring the cost of farm operations, since they are as much a part of the farm power plant as is the tractor.

Neither should it be forgotten that not only should the relative expense of operation with the two methods be considered, but also the relative results.

THE INCREASED crop acreage and consequent increase in income which the purchase of the tractor will often make possible may much more than offset a slight increase in the operating expenses of the farm.

QUALITY OF WORK.

Not a few farmers, when considering the purchase of a tractor, hesitate because of the fear that they may not be able to do the work as satisfactorily as with horses. This applies particularly to plowing. That there is little reason for this attitude is indicated by the fact that 37 per cent of tractor owners report that the quality of work done by the tractor is better than that done by horses, while only 2 per cent say it is poorer. The remaining 61 per cent see no difference.

The quality of work done in plowing does not depend so much upon the tractor as upon the plow and its adjustment. Under average conditions, the work done by most engine gang plows when properly adjusted is fully equal, and often superior, to the work done by either a walking or gang plow drawn by horses and operated by a skillful plowman. If a job of plowing where a tractor is used is not satisfactory, it is not usually the fault of the tractor, but of the plow, or, more probably, it is due to improper adjustment of the plows. Of course, in fields with obstructions, sharp angles, etc., the tractor may be responsible for poor work because of its clumsiness, but under most conditions the plows and the operator determine the quality of the work done. The tractor's part is to furnish the power to pull the plows.

This point should be kept in mind by farmers who select their tractors by visiting demonstrations of different makes of outfits. The quality of work done by different machines should be of value in selecting a good gang plow, but it is practically worthless in determining the value of the different tractors. It is quite possible that a tractor of very inferior quality may be pulling a good gang plow, well adjusted, and doing much better work than an outfit of first-class quality which is pulling a poor plow or one that is out of adjustment.

Depth of plowing.—The average depth of plowing done with tractors by the Dakota farmers who furnish data for this bulletin is slightly less than 6½ inches. The average depth they had previously plowed with horses was about 5 inches. While this deeper plowing is ordinarily considered as indicating a better quality of work, it does not appear to have had any marked effect on the crop yields, although increases from this cause were reported in a number of cases. (See p. 32.)

Disking plowed land.—As to the quality of disking, or other work on plowed land, it will of course, as with plowing, depend largely upon the implement drawn and the skill of the operator. The question of packing the soil is usually more important in connection with work on plowed land than in plowing, but that this is not a serious drawback with modern tractors in a large portion of the Dakotas is indicated by the fact that 70 per cent of Dakota tractor owners reporting say that their machines are satisfactory for use on plowed land.

As already stated, in certain parts of these States the soil is so heavy and so easily packed that it is possible under certain conditions for the wheels to injure the soil for the crop if the tractor is used in preparing the seedbed after the plowing is done. While 30 per cent of the owners report that their machines are not satisfactory for use on plowed land, this does not indicate that the soil conditions on 30 per cent of the farms are such as to make the tractor unsatisfactory in this respect, since some makes of tractors will do very satisfactory work in plowing, but do not handle well in soft ground. This fact accounts for a number of the reports of the tractor being unsatisfactory for use on plowed land.

OPERATION.

Since difficulty in operation is mentioned by tractor owners as one of the principal disadvantages of the tractor, it seems pertinent to state that though any man of ordinary ability can operate and care for a gas tractor very satisfactorily after a little study and experience, it is decidedly unwise for him to undertake to gain the necessary experience by experimenting with his own machine. In most cases he can obtain the experience more cheaply elsewhere. Experience in running stationary engines or automobiles, while of some

value, is not enough. The mere starting of the motor, changing of gears, and stopping are simple matters, and any farmer can learn quickly to do these, but the important thing is the ability to detect trouble the minute it begins to develop, and to be able to remedy it promptly instead of allowing it to run along until an expensive delay results.

A great many owners report that it is extremely difficult to get hired help capable of operating a tractor satisfactorily. Where a tractor is to be operated by inefficient help, it is very important for the owner to understand the proper care of the outfit in order to see that it is not abused.

The fact that a tractor does demand a certain amount of knowledge on the part of the operator is not a serious drawback. The necessary training usually can be obtained rather easily without great expense.

> **IT PAYS to spend a few days in gaining experience under a competent instructor, and it is unwise to attempt to run a tractor without such preparation.**

With the increasing use of tractors, as well as of automobiles and stationary engines, farmers are rapidly becoming familiar with the care and operation of gas engines. At the same time tractors are being improved and simplified so that difficulties in operation are growing less each year. One generation of well-trained and competent operators will disseminate information so that future generations will acquire knowledge on the subject as unconsciously, yet as thoroughly, as the average farmer's son acquires his knowledge of horses.

> **THE MISTAKE should not be made of assuming that any boy can operate a tractor in an efficient manner; only a proficient operator can handle a tractor properly.**

So long as the tractor is in first-class shape and everything working properly, of course a sturdy boy, or girl either, can guide and control it, and cases are not infrequent where a considerable amount of work has been accomplished with such operators. However, handling most tractors, even of the small sizes, is rather too strenuous and tiring work for a growing boy or girl, and a certain element of personal danger is involved with a tractor in the hands of such operators. There is also a greater risk of damage to the outfit in any emergency calling for quick and clear judgment or for considerable physical strength, and such emergencies are not uncommon.

Probably the greatest objection to inexperienced operators of this kind, however, lies in the fact that they are seldom capable of detecting the approach of trouble in the shape of loose bearings, etc., and will continue to operate the machine until the trouble develops to a point where a considerable delay and heavy expense result. The amount of work accomplished by a tractor of profitable size is sufficient to justify the time of one man in its operation in order to insure its efficiency. The use of young or inexperienced help, while justifiable in an emergency or in cases where close supervision is maintained by a competent operator, can not be recommended as a regular practice.

Some tractor manufacturers offer to give thorough instruction in the operation of their machines at a reasonable cost, and will usually credit the charge for such instruction as part payment on one of their machines if the student buys one. Purchasers of farm tractors should avail themselves of the opportunities thus offered to obtain training in the use of the particular machines they will be called upon to operate, which will go far toward insuring their success.

RELIABILITY.

The reliability of a tractor depends to a very great extent upon the ability of the operator. Of 281 tractor owners in the Dakotas who answered the question as to how many days their tractors were out of commission when needed, 139 (49 per cent) reported that their outfits were not disabled a single day when needed during the past season. Of the remaining 51 per cent, the average number of days their tractors were out of commission when needed was 6. This average, however, did not include five men who stated that their machines were out of commission a large part of the time.

The reports of tractor owners and the results of extensive investigations in the use of tractors indicate that with a careful and proficient operator a gasoline or kerosene tractor is a very dependable source of power. Occasional slight delays probably will be encountered, but serious ones will be exceptional, whereas, with a careless or incompetent operator, expensive delays may be frequent.

Of the tractors owned by Dakota farmers reporting, about 93 per cent are operated by the owner or some member of his family, the best results usually being obtained by this class of operators. Thirty-two per cent of Dakota owners reported no time lost in the field on account of trouble with the outfit. This probably means that the time lost was not worth mentioning. Most men do not consider it trouble so long as they know at once the cause of stoppage or other irregularity in the engine's operation and are able to remedy it promptly. The average time lost per day by the 68 per cent reporting trouble is a little over three-quarters of an hour.

DISPLACEMENT OF HORSES.

The tractor has not displaced horses to the extent commonly expected. Its greatest advantage, as above mentioned, has been in the fact that it does the heavy work quickly, and thus completes it within the proper season, since it places at the farmer's command a large amount of untiring power when needed.

The reports show that on Dakota farms horses are displaced by the tractor on only about 57 per cent of the farms where the tractor is bought and where no increase is made in the acreage farmed. The tabulation of the reports from 108 farms where no increase was made in the acreage after the purchase of the tractor showed that on 62 of these farms horses were displaced, while on 46 the same number were kept as before the purchase of the tractor. On the first group of 62 farms, with a total crop acreage of 18,904. or an average of 305 crop acres per farm, a total of 630 horses were kept before the purchase of the tractor, while only 406 horses are now used on these farms. In other words, an average of slightly less than four horses were displaced on each farm by the purchase of the tractor. From the above figures it will be seen that the number of acres cropped per horse in this group before the purchase of the tractor was approximately 30, while with the present arrangement only one horse is kept for each 46½ acres of crop.

On the second group of 46 farms, having a total of 15,553 crop acres, an average of 338 for each farm, 409 horses are now kept, the same as before the purchase of the tractor. On these farms one horse is kept for each 38 acres of crop. In the first group the horses previously kept were ample for the crop area on these farms under the system of farming followed in this section, and the tractor has reduced the number of horses kept by about 36 per cent. In the second group of farms the crop acreage per horse is slightly greater than that commonly found on farms in this region where horses only are used, but with the tractor to do part of the work it would seem as though the number of horses kept should either be decreased somewhat or additional acres added to reduce the investment per acre for power.

CROPPING SYSTEMS followed in the Dakotas are for the most part such as to permit the tractor to be used to better advantage than is possible in some sections of the country.

FEW MORE BROOD MARES KEPT.

While the raising of colts has not been as extensive an industry in the Dakotas as in some other sections of the country, nevertheless

mares have always constituted a large percentage of the work stock on farms in these States, and a considerable number of colts have been raised to meet the local needs as well as for a limited export business. It is frequently expected that where the tractor is used and the work stock thus relieved of the heavy field work, the percentage of brood mares kept will be increased, and that the chances of raising more and healthier colts will be enhanced. It is interesting, therefore, to note the effect of the use of tractors on the percentage of brood mares kept on Dakota farms. The reports of more than 200 tractor owners show that 37.6 per cent of all the work stock on these farms previous to the purchase of the tractor were brood mares. Brood mares now constitute 40.6 per cent of the work stock kept on these farms, showing an increase of only 3 per cent. This result checks closely with the figures obtained from Illinois tractor owners, as shown in Farmers' Bulletin 963.

CUSTOM WORK.

Nearly one-half (49.8 per cent) of all tractor owners in the Dakotas use their outfits to some extent for custom work. In some cases the tractor was bought with the idea of using it for such work, while in others it was procured primarily for use on the home farm, and custom work has been undertaken at the request of neighbors or because it seemed to offer an opportunity for the tractor to help pay for itself.

The use of a tractor at custom work for field operations seems a rather reliable indication that the home farm is not large enough to utilize a tractor economically. This conclusion is borne out by the fact that the average size of the farms owned by men who use their tractors for custom work is slightly less than of the farms where the tractor is not so used. In almost every case where the tractor is bought on a small farm, it is used for custom work. An efficient farm should be large enough to keep both labor and equipment employed during practically the entire working season. Of course, in the fall, after the work on the home farm is completed, it may be desirable to use the tractor for custom work, provided an adequate return can be obtained. This, of course, means that most of the custom work will be stationary operations, such as thrashing, shredding fodder, shelling corn, etc., which can be done after the weather is unfit for field operations. It is significant that the percentage of tractors used for custom work decreases as the size of the farm increases. In the group of farms shown in Table III on page 15, where the days of custom work decreased with the increase in the size of farms, the percentage of tractors used for such work also showed a similar decrease as indicated in the following table:

TABLE V.—*Relation of size of farm to use of tractor for custom work.*

Crop acres in farm.		Percentage of outfits used for custom work.	Average number of days tractor worked.		
Range.	Average.		Home farm.	Custom work.	Total.
160 and less	127	66.7	22	19	41
161 to 320	263	50.0	38	13	51
321 to 480	405	39.0	43	10	53
481 to 640	572	33.3	54	7	61

However, some doubt exists whether it pays as a general rule to use the tractor for custom work even under these conditions. Of these Dakota tractor owners who have used their machines for custom work, 13 per cent stated that it had not paid them. It should be noted also that comparatively few farmers consider their entire expenses when calculating the profits from this source. Most of them ignore depreciation charges, and include only fuel, oil, labor, and such repairs as may be required during the time the outfit is used. Under these conditions it not infrequently happens that a tractor owner does custom work at an actual loss, or at any rate at no real profit when all expenses are considered. On the whole it is preferable that the machine be kept busy on the home farm during as large a part of the working season as practicable, so that the owner may derive the maximum profit from its use.

A TRACTOR OWNER is not justified in neglecting his own work to accept employment on a neighbor's farm at the rates usually paid, although this is not an uncommon occurrence.

A little ready cash seems to blind some men to their own best interests and to the ultimate profit which should be made through the use of their machines at their own work.

EFFECT OF USE OF TRACTOR ON CROP YIELDS.

The reports of Dakota tractor owners were studied to ascertain what effect the tractor has had on crop yields. The answer to the questions which were asked on this point indicate that although increases are more common than decreases, they are not sufficiently frequent to warrant a farmer in attaching too much importance to this feature when considering the purchase of a tractor. The principal reasons for increases in yields were timeliness in having the work done and deeper and more thorough preparation of the seed bed in hot weather. Conservation of moisture due to the rapidity with which the work could be performed and the carrying on of more than one operation at a time also may have played a part. Decreases were usually credited to the packing of the soil when damp, and occasionally to delay in getting work done because of trouble with the outfit.

By far the largest percentage of owners, however, report no noticeable effect in either direction which can be attributed to the tractor.

Although the depth of plowing done with the tractor averages about 1½ inches greater than that done with horses, this seems to have had a rather negligible effect on yields. This is perhaps somewhat contrary to what is generally expected, but is doubtless accounted for by the fact that deep plowing alone does not necessarily increase the yields, other good farming methods and practices being required in connection therewith in order to make it profitable. Extensive experiments in the cultural methods for growing various crops in the Great Plains area show plainly that the weather conditions determine largely whether deeper plowing will result in an increase in yields. At the same time they clearly demonstrate that such increase in yield frequently does not offset the increased cost of the deeper plowing. The results of these experiments covering a long period of years are shown in United States Department of Agriculture Bulletins numbered 214, 218, 219, 222, and 268, covering the production of spring wheat, oats, corn, barley, and other crops in the Great Plains area.

TRACTOR EQUIPMENT.

For a number of years following the introduction of gasoline and kerosene tractors the only special equipment for use with these machines was the gang plow. Experience soon demonstrated, however, that a great many of the horse-drawn machines which could be attached behind the tractor were not sturdy enough for use with mechanical power, because the latter is more powerful and unyielding than horses, and machines used in connection therewith are subject to more sudden and severe jolts. As a consequence during the past two or three years more attention has been given to the development of disks, binders, and other machines especially constructed to withstand the heavier service.

It is obviously impossible to obtain maximum results with a tractor when it is used with implements designed primarily for use with horses, and the objection of many tractor owners that the tractor can not be used with profit for certain types of field work will probably cease to hold good with the further development of special machinery for use with the tractor. There is considerable activity at present in the line of further inventions of implements and attachments designed especially for use with the tractor. Many of these will doubtless increase its value for farm work, making it practicable and economical for many field operations where its use is now both impracticable and uneconomical. It is for the purpose of doing work of the nature last mentioned that several horses are often kept after the purchase of the tractor. With the development of special machinery as above outlined it seems probable that a higher percentage of work stock will be displaced where the tractor is used.

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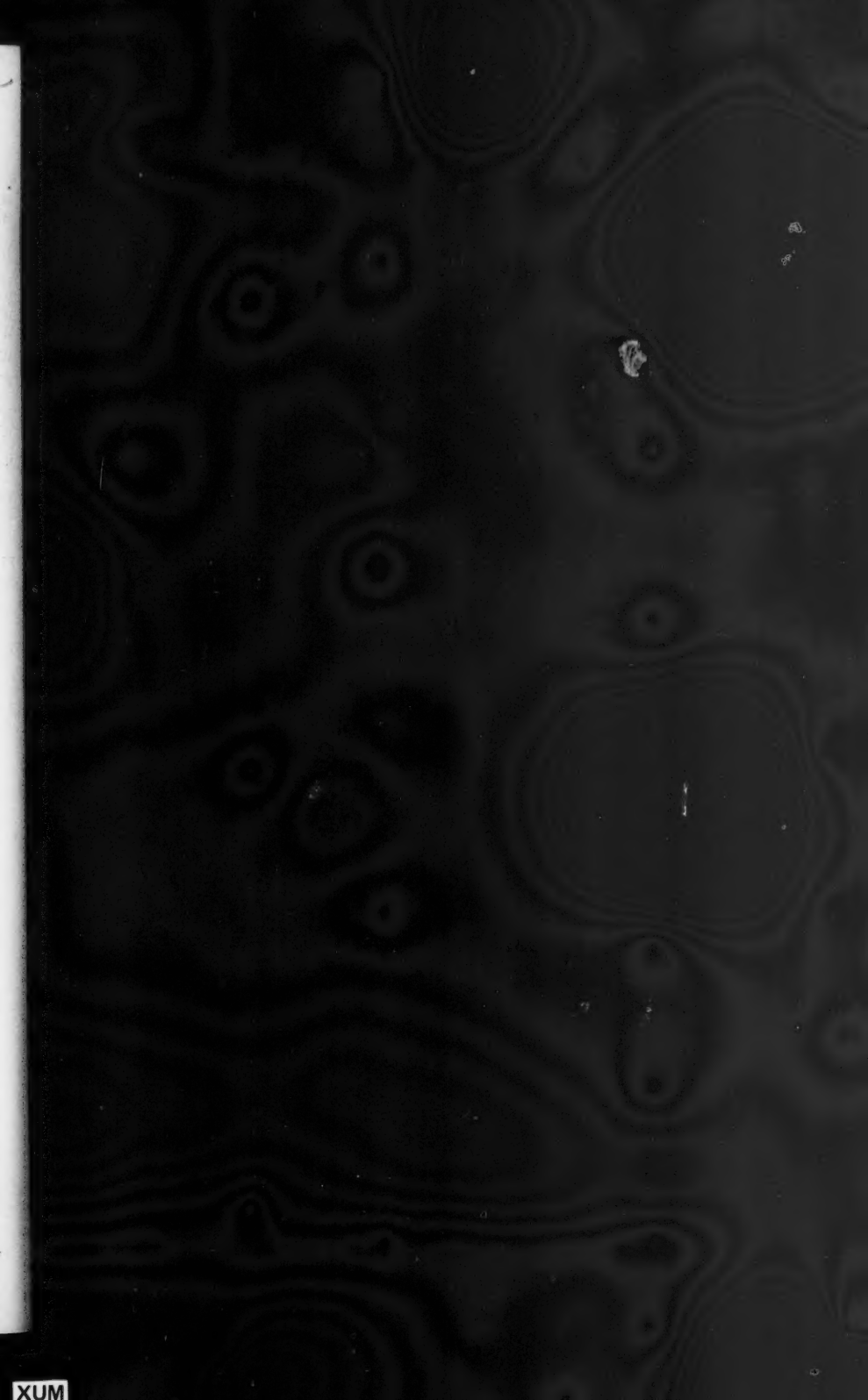
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